NASA Outer Solar System Exploration

Second International Planetary Probe Workshop

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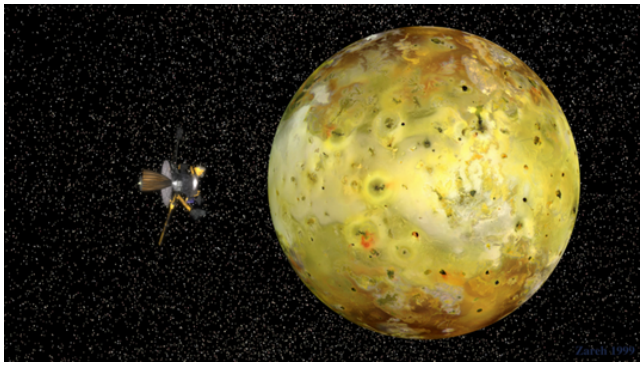
Completed Missions

Galileo



Salient Features

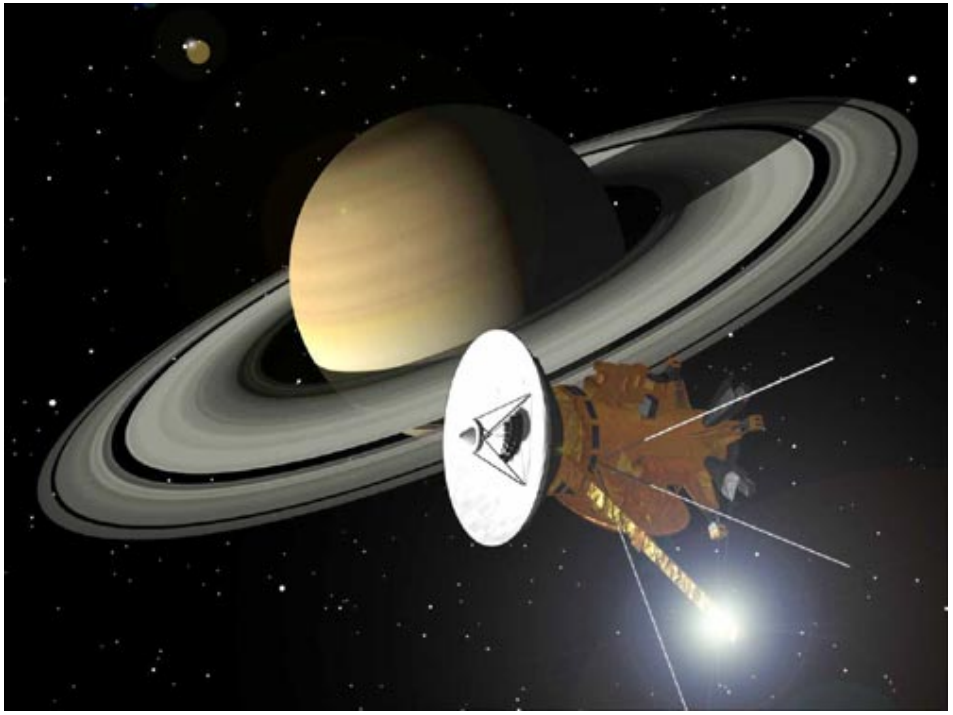
- The Galileo orbiter entered orbit around Jupiter and released its entry probe into Jupiter's atmosphere on December 7, 1995.
- Probe survived to approx. 20 bar pressure level
- Orbiter completed primary mission (GLL) and two extended missions: the Galileo Europa Mission (GEM), and the Galileo Millennium Mission (GMM).
- Disposed of orbiter by impact into Jupiter on September 21, 2003 for planetary protection (Europa)

Science

- Investigated the chemical composition and physical state of Jupiter's atmosphere.
- Studied the structure and physical dynamics of the jovian magnetosphere.
- Investigated the chemical composition and physical states of the jovian satellites and rings.
- Final phase of mission focused on the small moon, Amalthea, and on the inner magnetosphere.
- Particles and fields data collected to within 4 seconds of s/c destruction

Operating Missions

Cassini-Huygens



- Launched October 15, 1997
- Entered Saturn orbit July 1, 2004
- Huygens entry into Titan Jan. 14, 2005
- Four-year orbiter primary mission at Saturn

Science

- Determine the chemical composition and physical state of Titan's atmosphere and surface
- Investigate the structure and dynamics of Saturn's atmosphere
- Survey the structure and physical dynamics of Saturn's magnetosphere.
- Determine the chemical compositions and physical states of Saturn's satellites and rings.

Deep Space Network

Current State

18 antennas spread over 3 longitudes

Future [to enable higher data rates in the next decade]

Studies on RF arrays

Optical Communication [demo Mars 09]

Major Functions

Command s/c

Capture s/c telemetry

Tracking

Navigation

Currently Supporting

12 HEO, Lunar, L1 & L2 missions

13 Deep Space Missions

Orbital debris monitoring

Solar System Radar

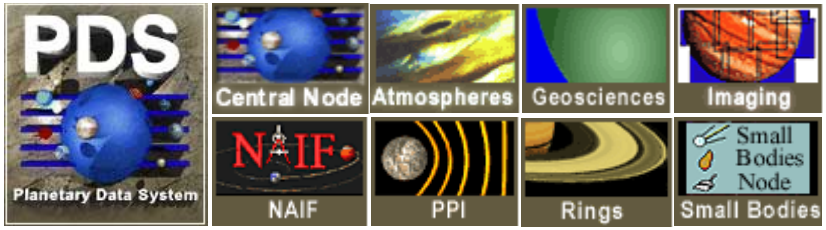
Radio Science

A Highly Reliable System

NASA has never lost a s/c due to a failure of the DSN

≥ 95% of telemetry is captured

Planetary Data System



Current State

Central Node at JPL (program management, coordination, system engineering)

Numerous Discipline Nodes at various NASA centers and institutions nationwide

Discipline Node scientists provide valuable link between PDS and the planetary science community

Future State

Very high data volumes

Enhanced query capability

Distributed computing

Major Functions

Curation of planetary/solar system data

Provide the public with a readily accessible on-line archive of peer reviewed datasets

Provide tools, ancillary data, metadata to enhance community interpretation of datasets

Currently Supporting

Archive and maintenance of past mission datasets (restorations)

Archive of current mission datasets (pipeline)

Preparation for future missions (coordination of interfaces, standard evolution and enforcement, coaching)

Issues

System evolving from a hard media archive to an on-line system

Existing Discipline Nodes currently being re-competed

Upcoming delta-review for Mars Reconnaissance Orbiter (MRO) preparation

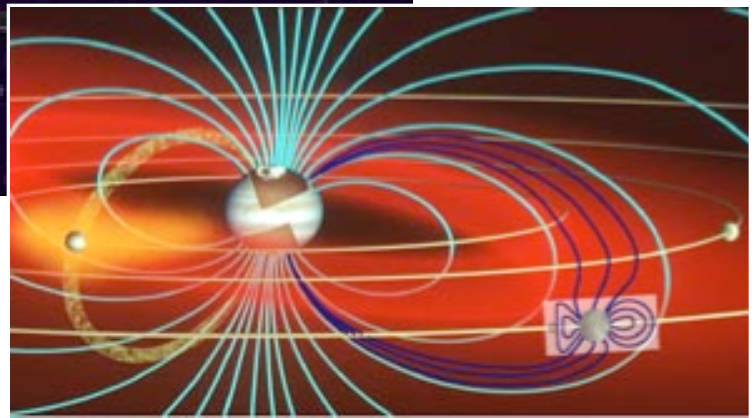
Missions in Development

Project Prometheus

- The “Project Prometheus Program” is located admini-stratively in the Exploration Systems Directorate
- PPP has two major objectives:
  - Develop fission nuclear power for space applications
  - Develop high-power in-space electric propulsion
- PPP is the implementing organization for future “flagship-class” science missions, the first of which is the Jupiter Icy Moons Orbiter (JIMO).
- All responsibility (and funding) for science on these missions resides in the Science Missions Directorate.

Jupiter Icy Moons Orbiter

- Global surface and subsurface characterization and exploration of the icy Galilean satellites
  - Launch ~2015
  - Sequentially orbit icy Galilean satellites
  - Extended Jupiter and Io observations
  - 4-6 year science lifetime at Jupiter
  - Potential small Europa surface package
- First use of nuclear reactor to power space science mission
  - Advanced high capability instruments
  - High data rate communications



JIMO Science Planning
Key Themes

- Research community involved through active and vocal Science Definition Team (SDT), with inputs from
  - NRC Decadal Survey
  - NASA Solar System Exploration Roadmap 2003
  - JIMO Forum (open to research community - "grass roots")
- SDT identified comprehensive science goals that can *only* be achieved with fission power and propulsion
- Iterative and open relationship between SDT and NASA communicated science requirements *vis a vis* technical limitations

JIMO Science Definition Team

- JIMO will address high priority science objectives identified by NASA and the science community:
  - 8 of 12 objectives in NRC Decadal Survey
  - 5 of 11 non-Mars objectives in NASA Solar System Exploration Roadmap 2003
- Hierarchy of 4 Goals, 12 Objectives, 43 investigations, and over 156 measurements
- Payload Accommodation Envelope provides
  - 1500 kg for science payload, including Europa surface package
  - Polar orbits of icy moons
  - Long durations at each icy moon and in Jupiter system
  - High power and high data rates for instruments

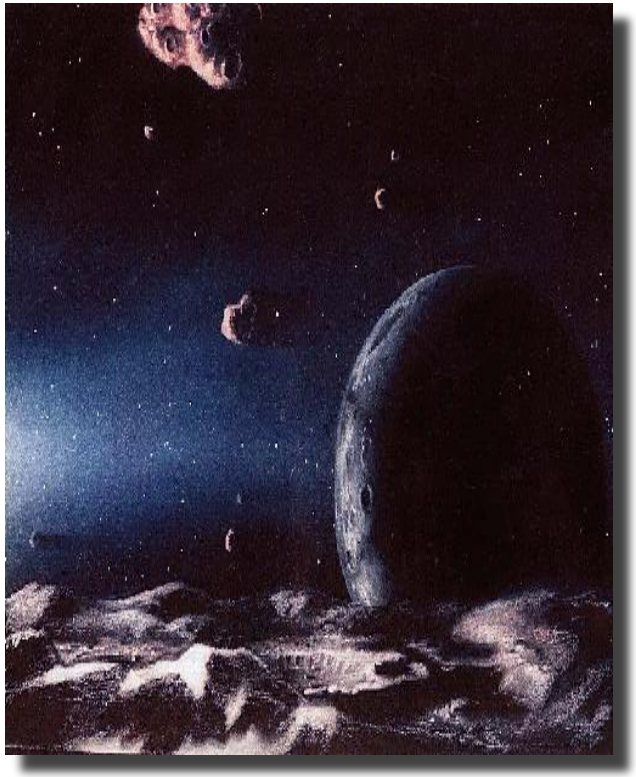
Only a fission-powered NEPP spacecraft can accomplish all of this in a single mission

New Frontiers Program

- NF will accomplish the objectives of the high-priority missions identified in the Decadal Survey that fit in the "medium" mission category:
  - **South Pole Aitken Basin Sample Return (SPA-SR)**
  - **Jupiter Polar Orbiter with Probes (JPOP)**
  - **Venus In-situ Explorer (VISE)**
  - **Comet Surface Sample Return (CSSR)**
  - **Kuiper Belt Pluto Explorer (KBPE)**
- New Horizons designated as first NF mission (KBPE)
- Competition underway for second NF mission
- AO for a new mission approximately every three years
- Cost Capped at $750 M in FY 03 Dollars, $35 M for MOs

New Horizons

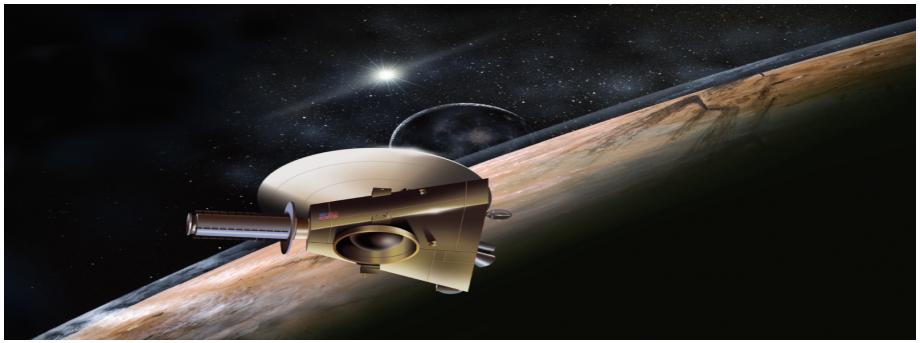
Characterize and Map the surface of Pluto and Charon, and Characterize the atmosphere of Pluto



Mission is scheduled for launch in January 2006

Nuclear (RTG) launch approval is major schedule driver

Production of cladded plutonium pellets at LANL is additional schedule risk



Traceability to Decadal Survey

- Highest priority recommendation: “flagship-class” mission (>$1B), Europa Geophysical Explorer (EGS)
  - JIMO meets and exceeds all science requirements for EGS
- Five high-priority “medium-class” missions to Pluto, Venus, Jupiter, Moon, and comet nucleus
  - New Frontiers program of PI-led medium class (≤$750 M) missions initiated in FY2003
  - New Horizons designated as first NF mission
  - AO issued for competition among remaining four missions. Expect to issue additional AOs at approximately three-year intervals
- Strong endorsement for continuing successful Discovery program of “small” PI-led missions

FUTURE MISSIONS

“Flagship” Missions

- Long-term strategy for outer planets exploration depends on fission power and nuclear electric propulsion (NEPP) to overcome traditional limitations in power, propulsion, communications, etc.

Flagship Missions

NEPP provides revolutionary capabilities for science far exceeding previous missions

- High power for instruments
  - Including active remote sensing
- High data rates during acquisition and transmission
- Large science payload mass
- High duty cycle
- Increased observation time at final destination
- High delta V capability

Flagship Missions

- Vision is for a fission-enabled flagship mission every 4 to 5 years beginning with JIMO
- SSB "Committee on Priorities in Space Science Enabled by Nuclear Power and Propulsion" will report next year.
- OPAG, a counterpart to the Mars Exploration Program Assessment Group (MEPAG), will involve science community in planning JIMO follow-on missions

Flagship Missions

- At a science workshop in June, the science community provided 7 mission concepts for JIMO follow-on missions:
  - Europa Lander
  - **Io Orbiter**
  - **Neptune/Uranus Orbiter**
  - **Saturn/Titan Explorer**
  - **Multiprobes to Multiworlds**
  - Interstellar Probe
  - **Primitive Bodies Explorer**
- 5 of the 7 missions call for probes
  - Penetrators, atmospheric probes, aerobots, etc.

Flagship Missions

Science return of JIMO follow-on missions must

- Be commensurate with the scale of these missions
  - Single NEPP mission can accomplish goals of multiple "conventional" missions (*i.e.*, high return on investment)
  - NEPP can enable science of different nature and scope than previously contemplated
- Fit within the framework provided by Decadal Surveys, Roadmaps, & Vision
- Be responsive to new discoveries

Medium Missions

- It is anticipated that future Announcements of Opportunity for New Frontiers will be opened to objectives beyond the five recommended in the Decadal Survey.
- Every three years, there will be opportunities to propose high-priority missions that can be accomplished
  - within a cost-cap of $750 M (FY03) and
  - with RPS or Solar power